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***APPLICATION
FOR
UNITED STATES LETTERS PATENT***

Title: METHOD OF COMPONENT REJECTION
FROM A PLACEMENT HEAD

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METHOD OF COMPONENT REJECTION FROM A PLACEMENT HEAD

Field of the Invention:

This invention relates to component placement machines and, more particularly, to the rejection of a component during
5 the placement cycle.

BACKGROUND OF THE INVENTION

10 The use of sophisticated placement machines in manufacturing printed circuit or similar cards, boards, panels, etc. is well known. The term printed circuit board (PCB) as used herein refers to any such electronic packaging structure. Typically, reels of tape-mounted circuit
15 components are supplied to the placement machine by multiple feeders. Each feeder holds a reel of components and each feeder assembly provides components at a pick station. A housing carrying a rotatable frame having a plurality of pick/place heads, each pick/place head having a vacuum spindle equipped with a nozzle, may be moved in the X and Y axes in a plane above the PCB being populated. Each vacuum spindle may
20 be moved in the Z-axis (i.e., in and out from an extended to a retracted position). Each nozzle is sized and otherwise

configured for use with each different size and style of component to be placed by the machine.

In operation, the housing carrying the rotatable frame is moved to the pick station and the nozzle of one of the pick/place heads is positioned over the tape-mounted component. The nozzle is lowered, via its associated vacuum spindle, to a point where, upon application of vacuum, the component is removed from its backing tape and held tightly against the nozzle orifice. The component is then brought to a vision system where an image of the component is taken and processed. One or more images of the component is captured by the vision system.

Analysis of the image(s) determines whether the component is placeable. Typically, a placeability decision is based on a comparison of the image to predetermined mechanical parameters for each component. If the component is placeable, the rotatable frame is moved to a point over the printed circuit board being assembled and the component deposited on the printed circuit board at a predetermined location. If a component is non-placeable, it is rejected into a reject station. With multi-pick/place head machines, the need to reject components efficiently to improve cycle rate has become more critical. The mechanical parameters used for comparison

may include, but are not limited to, lead length, lead width, lead spacing, component size, the number of leads, etc.

It is also known in the art to use a gripping mechanism
5 that may be extended and retracted in place of the vacuum spindle and nozzle.

In the past, when the nozzle of a particular pick/place head carried a component deemed non-placeable, the entire
10 housing and rotatable frame had to be moved in the X-Y plane to a designated reject station to release the component. This reject station may be a dump bucket, a reject feeder, or a matrix tray. Needless to say, as the entire multi-head rotatable frame needed to move, all other pick/place heads
15 thereupon were prevented from picking and placing components during the trip to the reject station. This resulted in lower placement machine throughput because of this motion.

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SUMMARY OF THE INVENTION

The present invention provides an improvement in the way that non-placeable components are handled in a component placement machine. During component rejection, wasted X-Y
25 axis moves degrade machine assembly time. The inventive apparatus and method allows components to be rejected during

each placement cycle by attaching a component reject station to the housing. In most cases, this eliminates wasted X-Y axis moves required to reject a non-placeable component.

Therefore, when the reject station resides contiguous with the 5 rotatable frame, the component rejection process in multi-head frames causes no slowdown of the placement machine cycle rate.

BRIEF DESCRIPTION OF THE DRAWINGS

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A complete understanding of the present invention may be obtained by reference to the accompanying drawings, when considered in conjunction with the subsequent detailed description, in which:

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FIGURE 1a is a detailed, schematic, front elevational view of the pick-up and place head of the invention;

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FIGURE 1b is a detailed, schematic perspective view of the pick-up and place head of FIGURE 1a;

FIGURE 2 is a simplified schematic block diagram of a portion of a component placement machine adapted to practice the method of the invention;

FIGURE 3 is a detailed perspective view of an on-the-housing reject station of the pick-up and place head of FIGURES 1a and 1b;

5 FIGURE 4 is a timing diagram of the placement cycle time; and

FIGURE 5 is a simplified flow chart of the method of the invention.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention pertains to rejection of a
15 component in a component placement machine having a housing with a rotatable frame upon which multiple pick/place heads are mounted for assembling printed circuit boards. The inventive apparatus and method features an on-the-housing reject station for receiving rejected components so that there
20 is no need for the rotatable frame to travel in the X-Y plane to a reject station to deposit one or more rejected components.

Referring first to FIGURES 1a and 1b, there are shown
25 both elevational and perspective schematic views, respectively, of a typical multi-head rotatable frame for use

in a component placement machine. The rotatable frame 104, having a plurality of pick/place heads 106 disposed around the periphery thereof, is mounted on housing 102. The rotatable frame 104 rotates around a central axis in the direction indicated by arrow 204 (FIGURE 2). Each pick/place head 106 has a vacuum spindle 108 having a nozzle 110 at a distal end. The vacuum spindle 108 of each pick/place head 106 is movable along a Z-axis between an extended position and a retracted position. In its extended position, the nozzle 110 can pick up a component 214 (FIGURE 2) at a pick station 203 (FIGURE 2). Also shown is the on-the-housing reject station 112 which is disposed on the housing 102 adjacent to the rotatable frame 104.

Refer now also to FIGURE 2. The pick station 203 provides a plurality of different component locations 206 from which a component 214 is selected in accordance with instructions provided, typically by a machine controller 210. Multi-pick/place head rotatable frames 104 are known and the concept forms no part of the present invention. Such rotatable frames are described in United States Patent Nos. RE. 35,027 and 4,458,412, as well as European Patent No. EP 0 315 799.

While the rotatable frame 104 is illustrated rotating around a horizontal axis, other configurations such as a

carousel, not shown, rotating around a vertical axis may also be used to practice the inventive method. Consequently, the invention is not considered limited to the rotatable frame 104 configuration chosen for purposes of disclosure.

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It is also known to use a vision system 212, typically having one or more cameras 202 disposed at a process station, not shown, of a component placement machine. Such vision systems 212 may be used to process images of components 214 to facilitate identifying, positioning, and manipulating or otherwise orienting the components 214 held against a nozzle 110 of a pick/place head 106. At least one camera 202 is disposed adjacent the rotatable frame 104 such that components 214 held on the nozzles 110 passing by the camera 202 are inspected. The camera 202 is used to capture images, not shown, often at different magnifications or with different lighting conditions. The output of the camera 202 is connected to electronic signal processing and control circuitry (i.e., a machine controller) 210.

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The machine controller 210 controls the camera 202 and provides image capture functions. An output of the machine controller 210 is connected to a vision system 212. A place station 208 typically holds one or more printed circuit boards 216 onto which components 214 are placed. An on-the-housing reject station 112 is attached to the housing 102 to which the

rotatable frame 104 is mounted such that components 214 rejected by the vision system 212 may be deposited therein.

The housing 102 to which the rotatable frame 104 is attached is typically movable in an X-Y plane allowing movement between the pick station 203 and the place station 208.

Referring now to FIGURE 3, there is shown a perspective view of one embodiment of the on-the-housing reject station 112. An opening 302 in the on-the-housing reject station 112 allows entry of rejected components 214.

The present invention takes advantage of the location of the on-the-housing reject station 112 to allow for rejection of a component 214 during the placement cycle performed by each nozzle 110 of the component placement machine. It will be recognized that many possible configurations exist for placing the on-the-housing reject station 112 in proximity to the rotatable frame 104 and that the invention is not considered limited to the embodiment detailed in FIGURE 3.

The inventive method is operative with any number of pick/place heads 106 and is not considered limited to any particular number thereof. It will also be recognized that

the timing data used for purposes of disclosure may vary depending on the actual design of the rotatable frame 104.

5 In the embodiment chosen for purposes of disclosure, it
is assumed under worst-case circumstances that each active
pick/place head 106 on the rotatable frame 104 may need to
reject a component 214 during each placement cycle.

10 In operation, after a component 214 has been imaged by
the camera 202 in cooperation with the machine controller 210,
the image is processed by the vision system 212. The image
analysis performed by the vision system 212 determines whether
the component 214 is placeable. The placeability decision is
typically based on a comparison of the image of the component
15 214 with predetermined mechanical parameters for the component
214. When the pick/place head 106 reaches the reject station,
and the component 214 is determined to be non-placeable, the
component 214 is released into the on-the-housing reject
station 112. If, however, the component 214 is determined to
20 be placeable, the nozzle 110 secures the component 214 until
it reaches the place station 208 where the component 214 is
placed on the printed circuit board 216 at its predetermined
location.

25 It will also be recognized that, optionally, functional
(i.e., electrical) testing may be performed on the components

214. The results of any such testing may also be used to identify a component 214 as non-placeable. There may be other testing or inspection which could be performed on components 214 and the inventive concept of on-the-housing mounting of
5 the on-the-housing reject station 112 is not considered limited to the specific tests identified for purposes of disclosure.

Referring now to FIGURE 4, there is shown a timing diagram for component rejection within a placement cycle. As may be seen, rejection of a component 214 for each pick/place head 106 is always completed within a placement cycle. By keeping component rejection completely within a single machine placement cycle, the component placement machine's throughput
10 is unaffected and the overall placement machine's throughput
15 is improved over similar machines of the prior art.

Referring again to FIGURE 1, FIGURE 2, and also to FIGURE 5, there is shown a flow chart 500 (FIGURE 5) illustrating the steps of the inventive method. The rotatable frame 104 is first moved to a pick station 203, a particular nozzle 110 associated with a pick/place head 106 is lowered, and a component 214 is picked, step 502. This step is repeated for
20 the number of pick/place heads 106 on the multi-head rotatable frame 104.
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After component picking begins, the nozzles 110 holding a picked component 214 proceed to the camera 202 where the component 214 is imaged, and the vision system 212 processes the acquired image, step 504. Assuming that the component 214 is determined to be placeable based on a comparison of the image with the predetermined criteria for component 214, step 506, the rotatable frame 104 is moved under program control to the desired X-Y coordinates over the printed circuit board 216 being assembled at the place station 208. The nozzle 110 is lowered and the component 214 picked in step 502 is placed onto the printed circuit board 216, step 510.

If, however, the component 214 is determined to be unplaceable, step 506, when the pick/place head 106 carrying the unplaceable component 214 on its associated nozzle 110 has proceeded to a position adjacent the on-the-housing reject station 112, the component 214 is rejected (i.e., released from the nozzle 110 into the on-the-housing reject station 112), step 508.

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Optionally, the on-the-housing reject station 112 may be equipped with one or more sensors (not shown) indicating that the on-the-housing reject station 112 is approaching a full state or has already reached a full state. Under program control, the frame 102 may then proceed to a dump station

where the on-the-housing reject station 112 may be automatically emptied.

In alternate embodiments, the placement machine having
5 the on-the-housing reject station 112 mounted on the housing 102 may have different reject options programmed. In one alternate embodiment, a component 214 being picked and placed by the component placement machine may be physically too large to be accommodated by the on-the-housing reject station 112.
10 In this case, the placement machine may revert to prior art behavior and move the housing 102 along the X and Y axes to a reject station where each oversized component may be rejected.

Since other modifications and changes varied to fit
15 particular operating requirements and environments will be apparent to those skilled in the art, the invention is not considered limited to the example chosen for purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of
20 this invention.

Having thus described the invention, what is desired to be protected by Letters Patent is presented in the subsequently appended claims.